A STUDY OF VEGETABLE OILS PERFORMANCE AS A HELICAL GEAR LUBRICANT

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OEM

ISO

AGMA

ASTM

API

SAE

ACKNOWLEDGEMENT

ABSTRACT

ABSTRAK

1.0 INTRODUCTION

Gears are used as power transmission dates back several hundred years. Before the introduction of iron and steel as the material that makes them, gears consisted of circular wooden wheels with wooden pegs fastened to the rims to serve as teeth. The power that used to operate these mechanisms were provided by man, animal, water or wind. Wear was not a major problem with the crude wood-tooth gears, but later, when cast iron gears came into usage, some form of lubrication is necessary whereby lubrication is other method to reduce noise. Greasy materials are known used to reduce noise those early days. Animal fats were about the only lubricants available, so they were used. They served satisfactorily because speeds and loads were low and mechanical wear on the teeth was not too serious. It was not causing so much trouble when the broken gear teeth are replaced.

However, by the time the steam engine was invented, gears were made of iron, which would hold or withstand greater loads and speeds. As the machine begin and continue to develop, gears of greater precision were required. At first, spur and straight bevel gears were enough and satisfactory, but with the advent of the steam turbine and electric motor, gear design became more of a science and the herringbone type was perfected. Then the process of gear cutting really became an art because precision and strength of metal had to be coordinated. Other types of tooth design which accompanied the development of automotive transportation and built in transmission units involved was the helical, spiral, bevel and worm gears. They paved the way for the hypoid gear which is virtually standard in automotive equipment today.

The objectives of the designers were to provide smooth running, quiet meshing and uniform hardness of the gear teeth to withstand wear. These objectives only can be achieved with effective lubrication. Modern industries today demand for greater power and speed than ever before to satisfy the increasing demand for more and more production. At the same time the turbines and engines that produce this power require gears that have greater toughness and higher precision than ever before. Only then power can be transmitted dependently into useful channels.

This question of gear tooth structure is all more important due to the common practice of deliberately overloading gears two or three times beyond their rated capacity in order to increase production. This demand for ever increasing production has placed a heavier load on the gears than perhaps on any other type of mechanism. It has been obviously shows that overloading will shorten the life of the gears, although it can be counteracted to a certain extent, but not completely, by the use of heavy duty type lubricants. The increased cost of gear displacement is felt by many to be justified by increased volume of goods produced.

Base oil type, oil viscosity, additive type and content have a strong influence on typical gear failures. In general, it is not possible to quantify the lubricant influenced on load carrying capacity simply from the knowledge of physical or chemical oil data. For better efficiency in transmission, lower viscosity grades of gear oils and less oil volumes are used. The introduction of lubricant properties in load carrying capacity rating requires not only knowledge of their physical properties as example viscosity, viscosity temperature or viscosity pressure behavior but also the quantitative influence on an extreme pressure oil scuffing, wear, micro pitting and pitting of gears (Hoehn et al. 2008).

In some axles, some transmissions, and some transaxles, gears of different designs are available for variety of service conditions. Selecting a lubricant for specific applications involves careful consideration of the operating conditions and the chemical and physical characteristics of lubricant. Gear oil is a lubricant made specifically for transmission, transfer cases, and differentials in automobiles, trucks, and other machinery. In the selecting of gear lubrication, consideration has to be given to the end application and the prevention of gear failure. Gears that demand longer service life operate continuously with high peripheral speeds; under moderate loads during operation require intermittent lubrication (Totten et al. 2003).

For the past several years vegetable oil has been identified to be used as gear lubricant. It has same potential as common synthetics lubricant. These oils propose important environmental benefits with regard to resource renewability and biodegradability, as well as

provide adequate performance in a broad range of application. Besides, the range price for vegetable oil is lower than synthetics oil.

Biodegradable means a substance that is able of being decomposed by bacteria and other living organism. Vegetable oil waste gives no harm effect to environment especially soil where in a particular time the fluid is converted to a lower molecular weight component. Environmentally reconcilable lubricants oil is progressively being used, for example in motor vehicle and equipment in water protection areas and in hydraulic engineering, in vehicle for agriculture and forestry. This oil is overtly degradable, non-toxicity and the water hazard is low (Antonsson, 2009).

Application of vegetable oils in industry is to support world concern towards Green Technology. Due to environmental concerns, vegetable oil finding its solution into lubricants for industrial and transportation application where scientists, engineers and inventors should know that green invention and technologies are good to our mother earth and can reduce energy bill, indeed offer safer and healthier products. Based on Condition Based Maintenance that has been implemented in nowadays industry, lubricant analysis is one of the ways to show that equipment is going to work well or fail in term of performance. Advance inspection can help engineer and maintenance team to identify the performance of vegetables oil as gear lubricants. The importance of good lubrication usually was not really been stress until a failure happen and has led to equipment failure and profit loss as the production was suspended. Bad maintenance practice was one of the main reasons that caused the problem. Therefore, lubricant analysis is beneficial to promote a good lubrication practices. The main purpose of the lubricant analysis in this study is to evaluate the performance of a sunflower oils which is a vegetable based oil is either have a potential in substituting synthetic lubricants which not readily biodegradable and expensive.

The primary function of lubrication is to help preventing excessive friction. Maintenance team must hold the responsibility in purchasing lubricants where it should be purchased on specification not because a matter of price. With the trend toward higher appreciation on earth has led to many case studies on performance of vegetable oils and its

chemical structure shows that it has superior benefits. Performance of vegetable oil has its constraint where its base stock have poor oxidative stability and low temperature solidification.

1.1 RESEARCH BACKGROUND

In industrial environment, maintenance is one of the few remaining areas of company expenditure that can be drastically improved upon. Apart from that, there are also other problems that must be faced in a company that is in operator error, machine design and poor material specification. Focus in cost maintenance, it is generally accepted and shows over 60 percent of mechanical failure related directly to poor or improper lubricant properties. Other than that, highly costs are involved to repair machine because the equipment are in failure to operate. Machine requires maintenance to keep them efficiently producing a quality product. Without friction, gravity, wear and other unpredictable problems, machine would operate effortlessly and run forever (Knotek, 2006)**.**

In a machine, there is one system known as the gear moves to generate movement generated by a motor. To prevent damage in the gear system, the lubricant should be used to avoid the damage. In this matter, there are three factors to be considered for selection of lubricants in term of management, equipment and lubricant (Bannister, 1996). Management and maintenance staffs have to adopt and commit to ensure proper lubrication techniques and training are utilized. This is especially important where the lubrication function and responsibility is passed along to the machine operator.

Energy is transmitted from the power source to a terminal point, through gears that change speeds, directions, and torque. In other words, a gear is a machine element designed to transmit power and motion from one mechanical unit to another (Amarnath et al. 2008). For most of the modern industrial and transportation application, gears are important and are frequently used as fundamentals components.

In the development of gear drives in the future, continuous demand for higher efficiency and reliability, increased load carrying capacity and endurance life, smaller size, lower weight, lower noise and vibration are the characteristic that the customer need to apply in their machine (Michaelis & Otto, 2009).

Gear can fail in many different ways, and except for an increase in noise level and vibration. There is often no indication of difficulty until total failure occurs. In general, each types of failures leaves characteristic clues on gear teeth and detailed examination often yields enough information to establish the cause of failure (Osman, 2005). The failure of the gear can no longer efficiently do the job for which it was designed. It because the failure may range from excessive wears to catastrophic breakage. In a gear train, many cases can be prevented. When it does occur, the proper redesign will ensure the trouble free unit and the most important this is to recognize the type of incipient failures (Eugene, 1967).

Therefore, to avoid failure gears mode in the gear surface, the gear lubricant should be apply. Lubrication is the process of applying lubricants. Lubricants are substance applied to mating surfaces to reduce friction, prevent corrosion and wear, provide a barrier against contaminants and assist in cooling. The main function of lubricants is to form a fluid film between moving machine components. If a lubricating film separates the solid objects, the amount of friction is less and the mating surfaces are not abraded through contact with each other.

Lubrication had affects friction and moving parts called tribology. Tribology is the science of the mechanisms of friction, lubrication and the wear of contacting surfaces that are in motion (Knotek, 2006). In the other words, the purposes of lubrication are process to reduce friction and failure of gear damage between two surfaces and to make smooth or slippery in gear operating. Besides that, the other functions of the lubricants is to reduce the high temperatures found in the movement of the gear and also prevent or minimize the corrosion on the surface of the gear if the system is not functioning (Bannister, 1996).

Now days, the use of synthetic oil is to use the new technology environmentally friendly technology, better known as green technology. This technology is the use of the environmental science to conserve resources becomes more depletion. The green technology is applied in the manufacture of lubricating oil to replace the mineral or synthetics lubricants. From example the creation of a versatile vegetable oil to do same things done and same characteristics by synthetic oils even further especially in the use of oil as lubrication to gears in machining operations. The source of vegetable oil can be renewed because this oil was produced from vegetation like fruit, nuts and flower.

Generally, friction is a major factor for failure and cause damage to gear in operating. It's proven why lubrication should be in the gear system. In the manner of friction occurs and it causes the warming at the surface of the occurrence of hot gear. When there is heating, expansion will occur in gear rottenly made from iron material. If the both surfaces are in touch, impending break off will happen known as brittle. So, it is essentially by applying lubricant in the gear system in the right amount, place and time.

1.2 PROBLEM STATEMENT

Common synthetics lubricants which are widely used in industrial application are made from mineral resource such as petroleum. However, this resource is become less in the future. Vegetable oils are reserve to find their way to fulfil the demand of industrial lubricant application. Besides that, rapid depletion of world fossil fuel reserves and increasing concern for environmental pollution from excessive mineral oil use and their disposal has increase the need of renewable and biodegradable lubricants such as vegetable based lubricant. Common synthetics lubricant show low biodegradability compare to vegetable based lubricant. For century, synthetic oils have predominant lubrication and today the environmental issue start to arise as synthetic oil is not readily biodegradable. Vegetable oil composes good physical properties to replace synthetics oil but its performance is questionable.

1.3 OBJECTIVE

The objective of this research is to evaluate performance of vegetable oils which are sunflower oil, soybean oil and corn oil as a lubricant for helical gear application. From the finding, the performance of vegetable oils will be compare to the performance of synthetic lubricant. Finally, we will know how good vegetable oils as a gear lubricant for an alternative for synthetic lubricant.

1.4 SCOPE OF RESEARCH

The experimental testing will be done using gear test rig. The oil sampling method is used to take the oil sample from gear test rig. The evaluation of oil performance as a gear lubricant of three types of tested oil which are sunflower oil, soybean oil and corn oil are done by using viscometer. The data findings will be compared to the ideal synthetic gear lubricant. The experimental testing will be held at Maintenance Laboratory, Faculty of Mechanical Engineering (FKM) in Industrial Campus, Universiti Teknikal Malaysia Melaka (UTeM).

1.5 RESEARCH DETAILS

1.5.1 RESEARCH REGISTRATION

The research is conducted under Sustainable Maintenance Engineering Research Group (SuSMe) register under Short Term Grant no. PJP/2012/FKM(30A)/S01033 sponsored by Centre for Research and Innovation Management (CRIM), UTeM with research duration from 1 June 2012 to 30 November 2013.

1.5.1 RESEARCH OUTCOME

a. Novel theories/New findings/Knowledge

The evaluations of a vegetable oils performance as a gear lubricant by comparing the performance characteristic analysis of vegetable oils to the synthetic lubricant are established. Beside, how good vegetable oils usages as a lubricant in gear application are now known.

b. Research Publications

These findings are produced an article which are submitted to three conferences;

1. 6th International Engineering Conference on Energy and Environment (ENCON 2013), Organized by Faculty of Engineering, Universiti Malaysia Sarawak.
2. Seminar Kebangsaan Aplikasi Sanins dan Matematik 2013 (SKASM 2013), Organized by Fakulti Sains, Teknologi dan Pembangunan Insan, Universiti Tun Hussein Onn Malaysia.
3. 3rd International Conference and Exhibition on Sustainable Energy and Advanced Material (ICESEAM 2013), Organized by Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka.

c. Specific or Potential Applications.

The vegetable oils performance development as a lubricant in a gear application.

1.5.2 RESEARCH BUDGET

Research budget allocation approved by University Research & Innovation Committee is shown in Table 1.1.

Table 1.1: Research budget allocation.

BUDGET		
Budget details	Amount approved	Amount Used
Vote 29000 (Temporary & Contract Personnel)		
Vote 21000 (Travelling Expenses and Subsistence)	**RM 4,000**	Travelling & Accomodation : RM 1,700 Conference Fee : RM 2,300 **TOTAL : RM 4,000**
Vote 24000 (Rental)		
Vote 27000 (Research Meterials & Supplies)	**RM 6,000**	Books : RM 500 Oil samples : RM 3,000 Testing probes: RM 2,000 Containers : RM 500 **TOTAL : RM 6,000**
Vote 28000 (Maintenance and Minor Repair Services)		
Vote 29000 (Special Services)	**RM 1,000**	Printing and binding : RM 1,000 **TOTAL : RM 1,000**
Vote 35000 (Special Equipment - Fix Asset)		
Vote 36000 (Accessories-Inventory)	**RM 3,000**	Benchtop Resistivity Meter : RM 3,000 **TOTAL : RM 3,000**
TOTAL AMOUNT	**RM 14,000**	**RM 14,000**

1.5.3 RESEARCH ACTIVITIES

In the process of carry out this experiment, Flow chart as shown in Figure 1.1 and Gantt chart as shown in Appendix A are prepared to assure the work is implemented as plan.

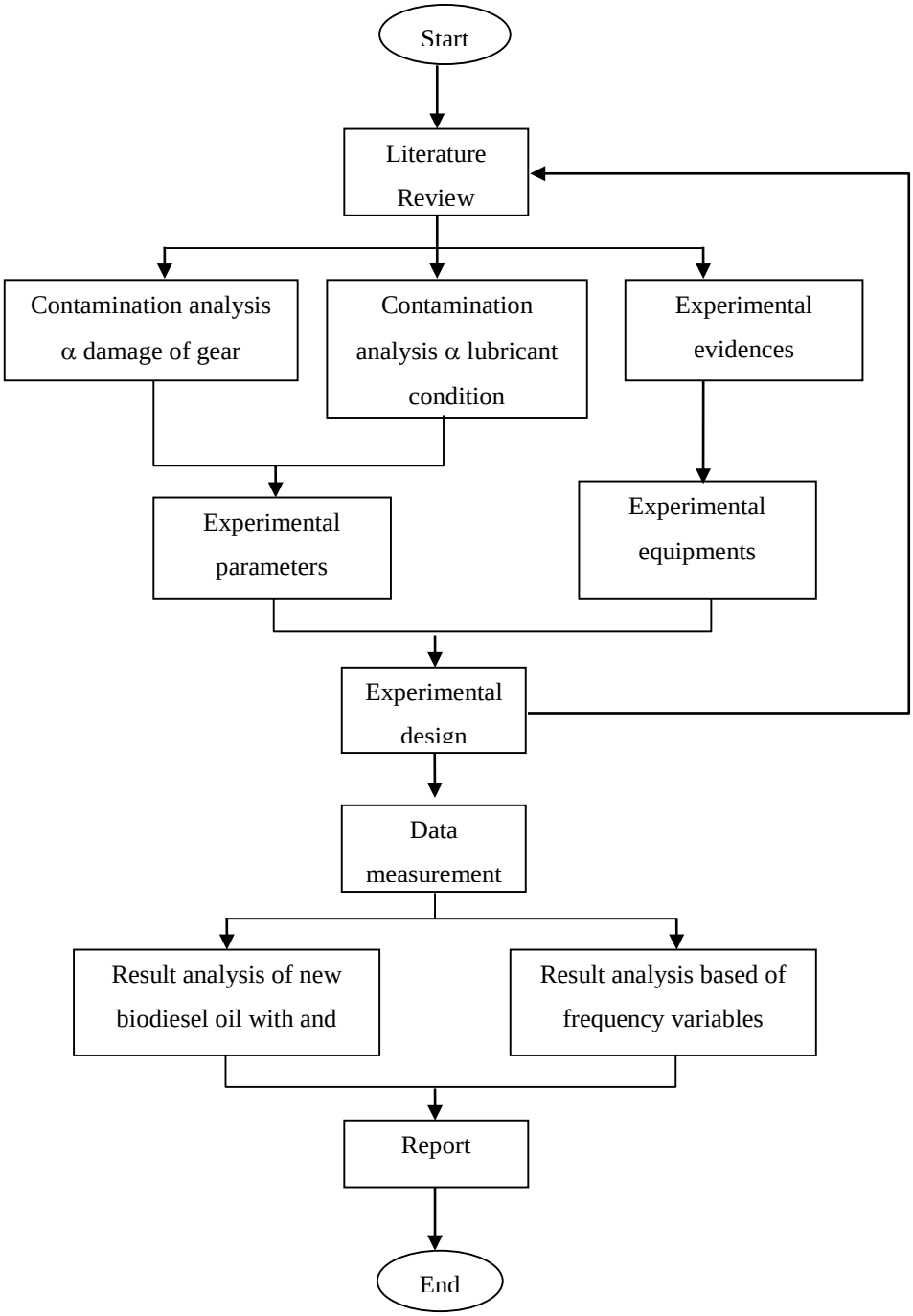

Figure 1.1: Research flow chart.